Diamond Shamrock
Thermal Power Company

Ralph A. Patterson, Jr.
Hawaii Project Manager

3 September 1987

Mr. William F. Quinn
Chairman
Governor's Cable Advisory Bd.
Goodsill, Anderson, Quinn
and Stifel
P.O. Box 3196
Honolulu, Hawaii 96801

Dear Mr. Quinn:

Enclosed please find an outline of our presentation to the Governor's Advisory Board scheduled for Tuesday September 8, 1987. It will be a pleasure to acquaint you and other members of the Board with some background and the current status of our Puna Geothermal Venture project in lower Puna. We will also be pleased to discuss some of the concerns that we have for the future development of Hawaii's geothermal resources.

In the interest of providing more details and background which we will not have time to fully discuss at our presentation, I have included some excerpts from our draft Environmental Impact Statement which we recently submitted to the County of Hawaii. I believe that it will be helpful to the Board members for two reasons.

1. It more fully describes the complexity and variety of elements that go into the development of a geothermal project such as ours, and

2. It describes a project that has been specifically designed with Hawaii's geothermal resource environment and development conditions. Thus, it may give you and the other members of the Board some specific insight into the Hawaii conditions affecting these developments.

It is our firm belief that the development of Hawaii's geothermal resources, both to serve the Big Island and the rest of the State through the proposed underwater cable system, is vitally dependent upon success of the Puna Geothermal Venture in putting this first commercial power plant into operation in the near future.

Successful completion of our development schedule will assure that private industry, the State and the County, will then have the knowledge and confidence absolutely necessary, to move forward with larger scale geothermal developments. Only in this way can we truly plan for wider development of the resource with which Hawaii is so abundantly blessed.

We look forward to meeting with you and your committee and to early success in our endeavors.

Sincerely,

Ralph A. Patterson/cm

encl
RAP/cn/0219A

cc: R. K. Burbank
Board Members

PUNA GEOTHERMAL VENTURE PROJECT

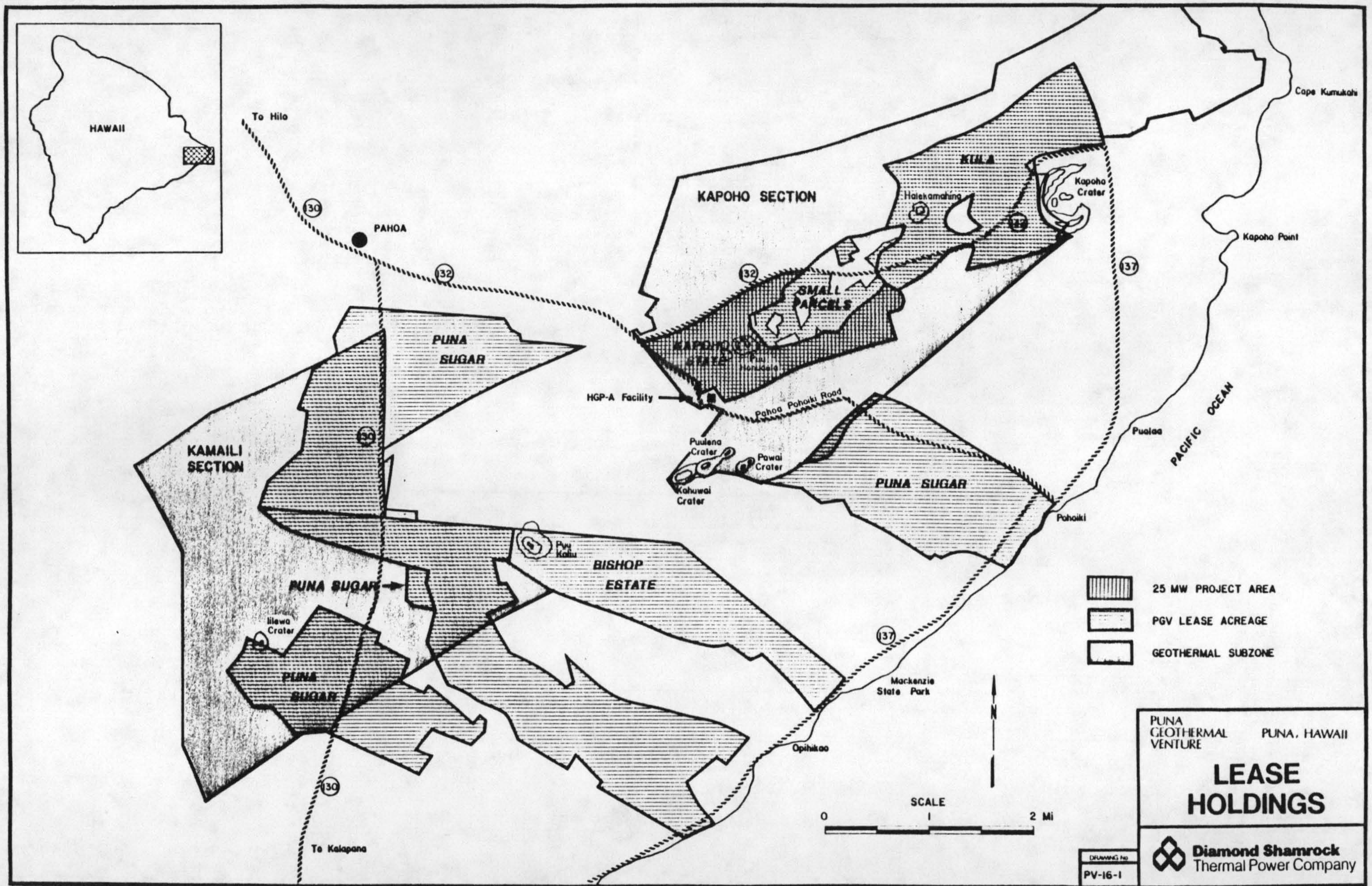
GOVERNOR'S ADVISORY BOARD ON THE UNDERWATER CABLE TRANSMISSION PROJECT

SEPTEMBER 1987

PUNA GEOTHERMAL VENTURE

Cable Advisory Board Meeting
8 September 1987

- JOINT VENTURE
- LEASES
- EXPLORATION WELLS
- POWER SALES CONTRACT
- EIS AND PERMITS
- ENGINEERING DESIGN
- REMAINING ISSUES
  - PERMITS
  - MARKET
  - SCHEDULE
  - COSTS
  - RESERVOIR
- SUMMARY



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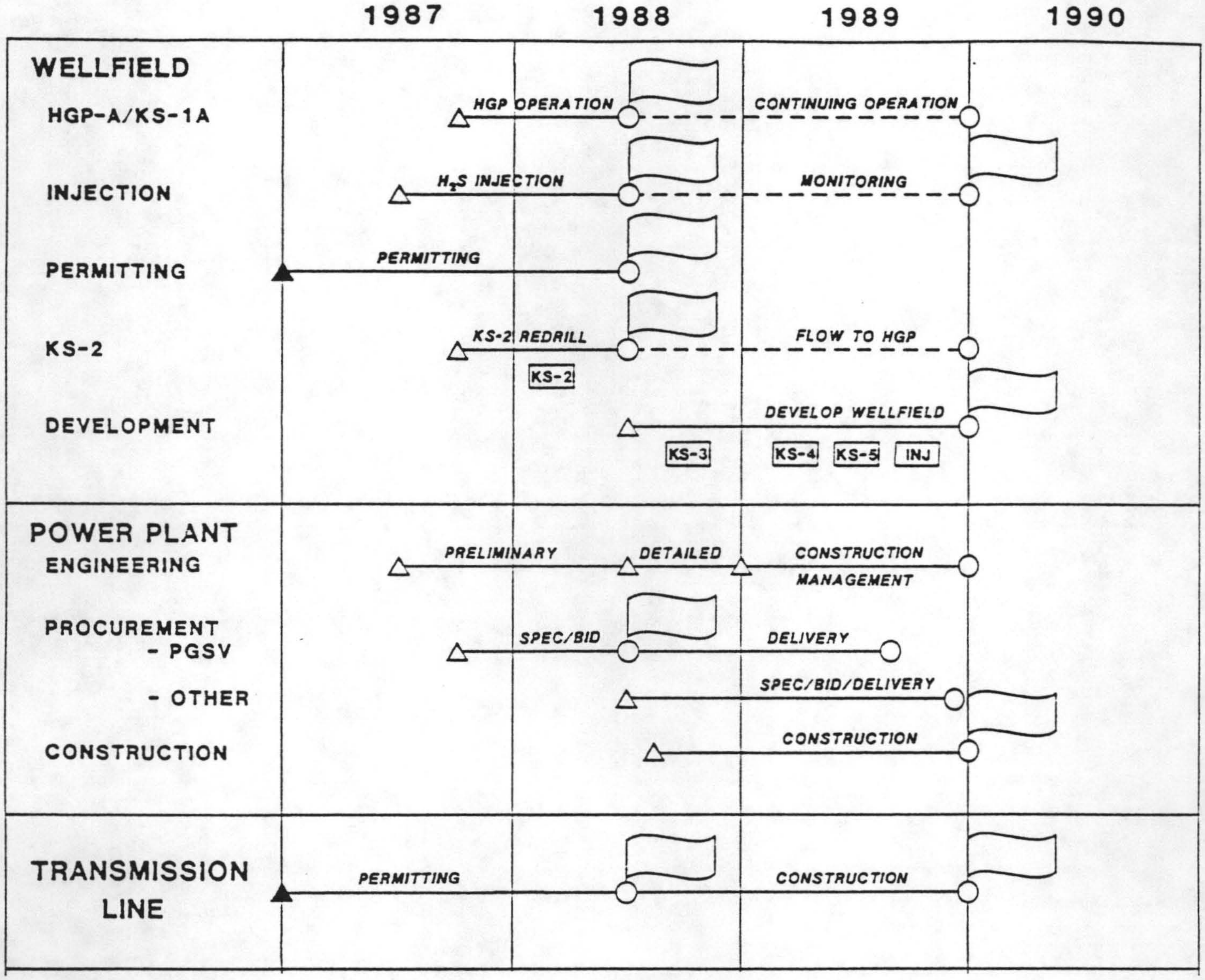
PUNA GEOTHERMAL VENTURE
PROJECT SCHEDULE



PGV 25MW PROJECT

The PGV project is a joint venture between Thermal Power Company (TPC) and AMFAC Energy, Inc. TPC is the operator of the project, and is an industry leader in the development of geothermal resources.

The Puna Geothermal Venture (PGV) project is a geothermal power facility consisting of an electric power plant and supporting wellfield facilities. The power plant uses geothermal steam to drive a steam turbine generator and produce electrical power. It is designed to provide 25 megawatts (MW) of electricity to the Hawaii Electric Light Company's (HELCO's) energy grid system for island-wide use. The generated electricity will help meet an energy need on the Big Island, and reduce the island's dependence on imported oil.

PROJECT DESCRIPTION

The proposed project is located on the island of Hawaii in the Puna District, approximately 21 miles southeast of the city of Hilo (see Figure 1-1).

A site plan of the facility is presented on Figure 1-2. To ensure delivery of 25 megawatts, the power plant is designed for gross production capacity of 30 MW. The excess capacity will be utilized by the power plant for internal energy requirements and to make up transmission line losses.

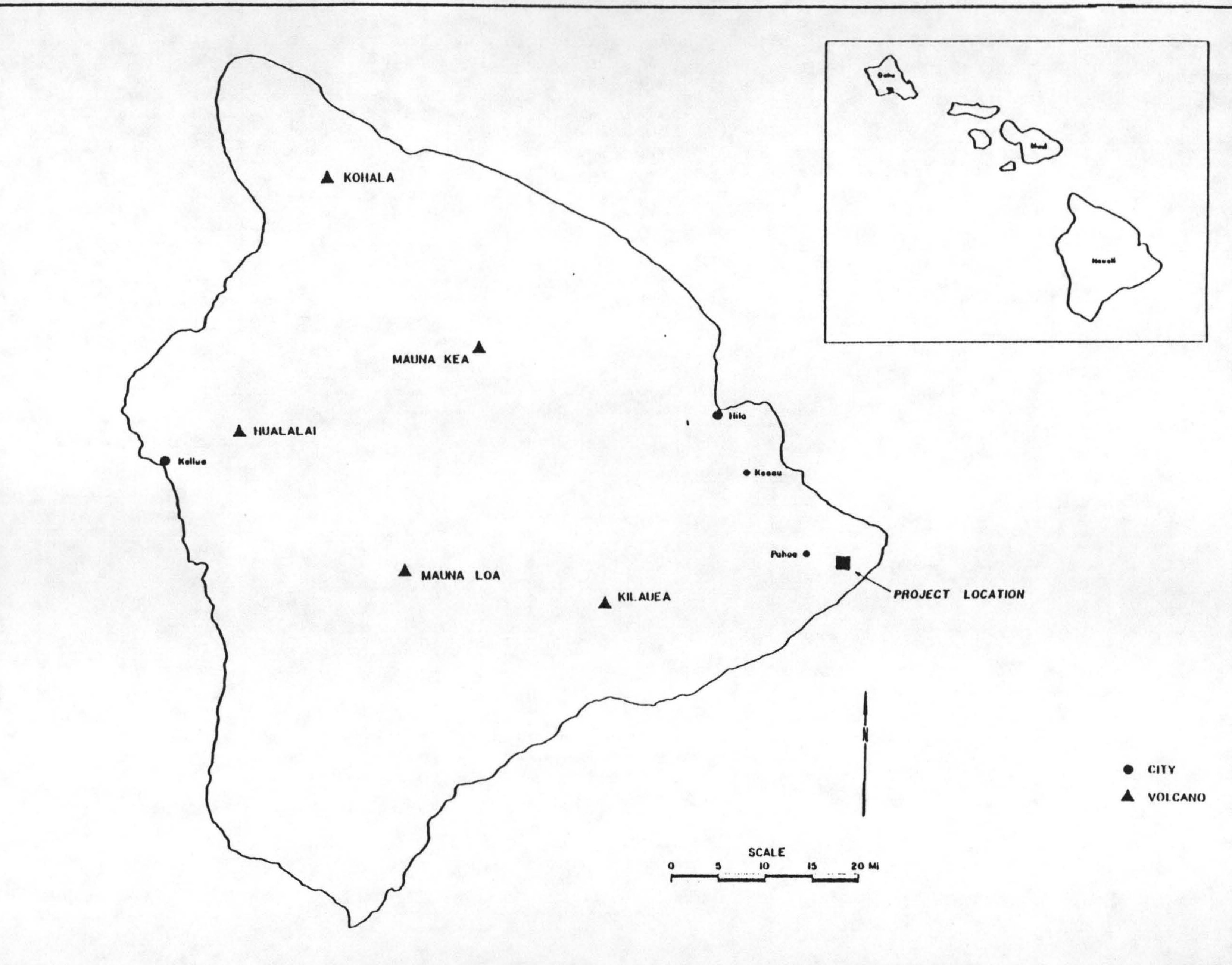


Figure 1-1 PROJECT SITE LOCATION

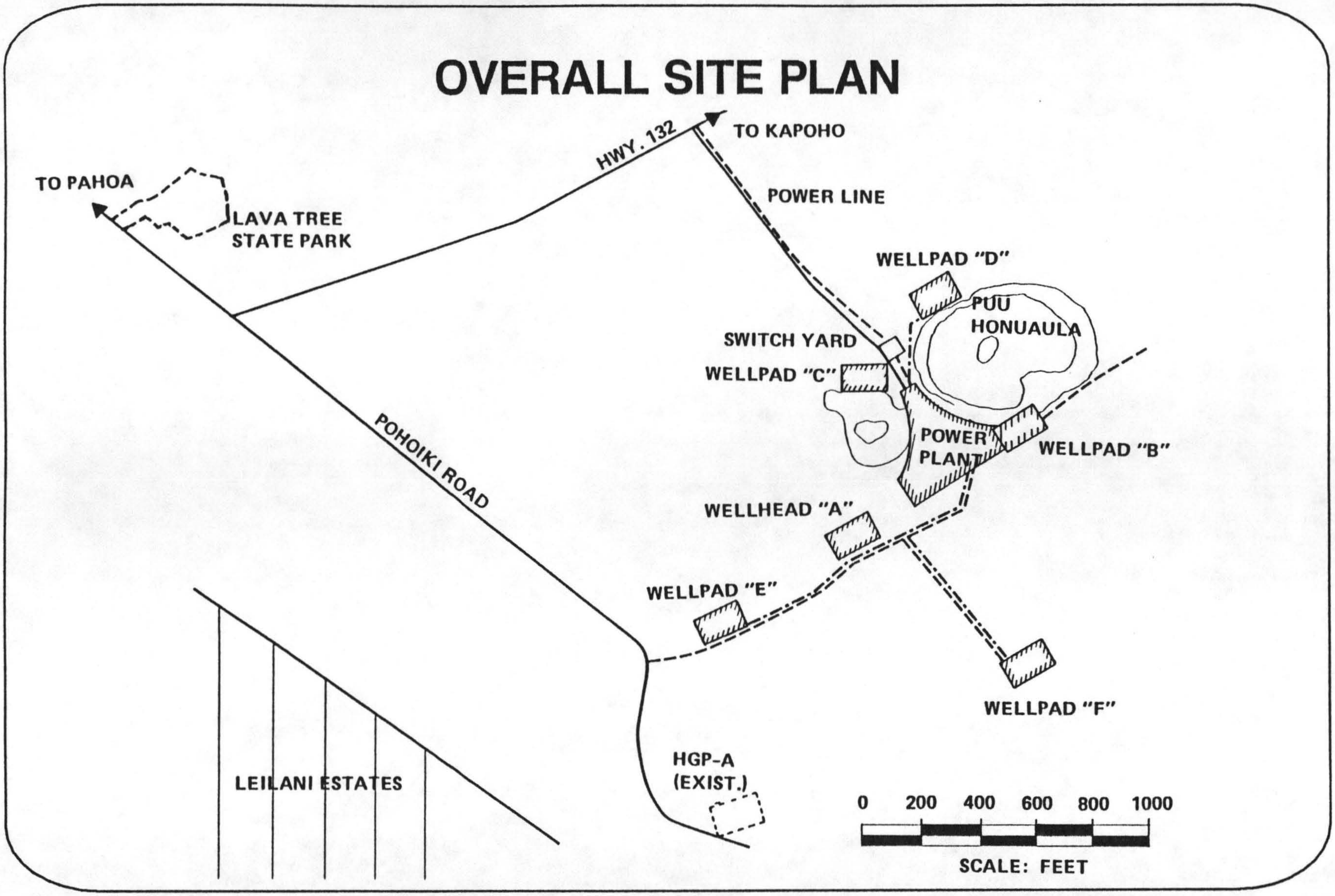


FIGURE 1-2

5J/B4551/00150

The project is located on approximately 500 acres within the 6,800-acre Kapoho Geothermal Resource Subzone, along the Lower East Rift Zone of Kilauea Volcano. The rift zone is one of the conduits for lateral migration of magma from the holding chamber beneath Kilauea's summit caldera, providing the heat source for the PGV project. Geothermal fluids are found between 4,000 and 7,000 feet beneath the surface and are above 600^{o}F in temperature.

A power transmission line will be needed to transmit power to the HELCO grid system. Environmental studies for the transmission line are being prepared by HELCO.

GEOTHERMAL POWER IN HAWAII

The utilization of the natural heat sources present in Hawaii's volcanoes is not a recent idea. Over 100 years ago, in September of 1881, the last king of Hawaii, King David Kalakaua, made inquiries about the use of one of the most powerful resources of his island kingdom: geothermal resources. King Kalakaua and several of his close advisors paid a visit to the celebrated scientist and inventor Thomas A. Edison in his New York quarters. King Kalakaua was introduced by Mr. George Jones, proprietor of the New York Times. Mr. Jones met King Kalakaua in Vienna, during the King's trip around the world, and had offered to set up a meeting with Mr.

Edison. The King was interested in Mr. Edison's electric light and the possibility of using it to replace the kerosene lamps being used in Honolulu.

The King was reportedly impressed by Mr. Edison's plans to sell power as well as light, and Mr. Edison was questioned about the possibility of using submarine cables to transmit electricity. Kalakaua's party inquired about the practicality of using the "volcano that burns a thousand million tons of coal a day" to put "boilers on top of the volcano and get power enough to supply this (the United States) country." The King's Attorney-General, when answering a question about the source of coal for the islands, commented that "we build great hopes on that volcano."

Honolulu eventually received its electricity, but it was not from volcano-produced electricity transmitted by submarine cables. The concept of using the power of the volcano for electricity production, now known as geothermal energy, has only been actively pursued in recent years.

The vision of Hawaii's King can be seen in the practical side of the harnessing of nature's gift of geothermal power. The ideas of Hawaii's last King can now bring increased benefits in energy supply and security. Although the PGV geothermal facility is not discussed in the simple terms that King Kalakaua used, the basic concept is the same.

Geothermal heat was first explored for commercial use in Hawaii in 1961 when four test holes were drilled in the Kilauea East Rift Zone by a private company. Twelve years later, a research well was drilled at the Kilauea summit to a depth of 4,141 feet. The temperature of fluids at the bottom of this well was 275°F, and there were indications of much higher temperatures at greater depths.

At approximately the same time, the University of Hawaii started an exploration program which resulted in the drilling of the HGP-A, drilled in 1976. The HGP-A well has the distinction of being the hottest well in the United States, with a measured bottom hole temperature of approximately 676°F. A 3 megawatt power plant was constructed in 1981 adjacent to the well and has been operating continuously since then. The HGP-A facility established the technical feasibility of commercializing geothermal resources on the Big Island and demonstrated reliability of operation.

The Federal government was the owner of the well and plant until late 1986, when ownership transferred to the State of Hawaii. HELCO has been the operator of the facilities since 1982. In early 1987, TPC signed an agreement under which it will become the operations and maintenance contractor for the HGP-A power plant. Use of the HGP-A plant will enable long-term flow tests of existing nearby exploration wells.

The following section provides an overview of the geothermal fluids underlying the site, the geothermal wells (production and injection), well pad facilities, and power plant systems. It also summarizes the proposed pollution abatement technology: closed-loop production, utilization and reinjection systems for the geothermal fluids.

LOCATION AND DESCRIPTION OF GEOTHERMAL RESOURCES

GEOTHERMAL RESOURCES SUBZONE

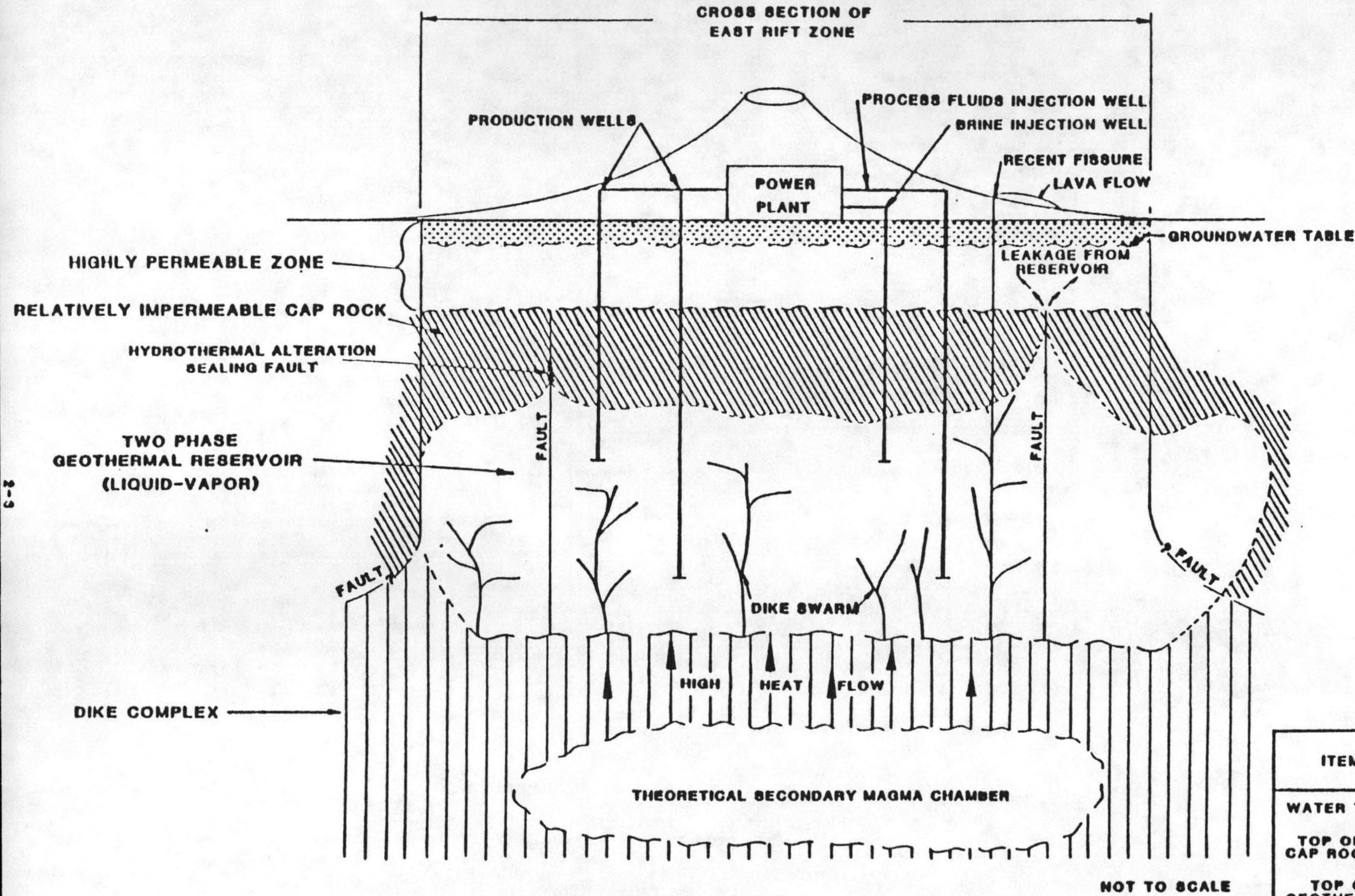
In 1983, the State of Hawaii legislature mandated the designation of geothermal resource subzones in which geothermal exploration and development could be considered by appropriate State and County permitting agencies (Chapter 205, Hawaii Revised Statutes (HRS)). The subzones are defined as areas of significant geothermal potential where the positive economic and social benefits of the development outweigh the potential negative environmental and social impacts. Only those areas designated as geothermal subzones may be used for exploration, development and production of geothermal resources.

The project will be developed on approximately 500 acres of the 816-acres subleased from the Kapoho Land Partnership (KLP) within the Kapoho Geothermal Resource Subzone. The sublease includes both surface and geothermal rights. KLP holds the surface rights to the parcel and has obtained a State of Hawaii Geothermal Resource Mining Lease (R-2), covering the rights to the geothermal resources. It was necessary for KLP to obtain a State geothermal lease for the property, because the State of Hawaii claims ownership of the geothermal resources. KLP's State lease was assigned to PGV.

GEOTHERMAL RESOURCE

The Puna geothermal resource is situated in the East Rift Zone of the Kilauea Volcano, one of the world's most active volcanoes; the summit is approximately 25 miles west of the project site. Well drilling data indicate that the Puna geothermal reservoir is a very high-temperature (over 600^{o}F), two-phase (vapor-liquid) resource. The reservoir is believed to be maintained by a very high heat flow within the rift and by an effective overlaying cap rock seal which inhibits significant venting. A conceptual model of the Puna geothermal resource is shown as Figure 2-1.

The Puna geothermal reservoir is characterized by a dike complex. Dikes within the complex increase in number with depth. The top of the reservoir occurs at about 4,000 feet below the surface. The geothermal reservoir is believed to extend to at least 7,200 feet below the surface.



ITEM	DEPTH BELOW GRADE
WATER TABLE	~ 600'
TOP OF CAP ROCK	~2500'
TOP OF GEOTHERMAL RESERVOIR	~4000'

Figure 2-1 CONCEPTUAL MODEL OF THE PUNA GEOTHERMAL RESERVOIR

A relatively impermeable cap seal extends upwards from the 4,000-foot depth to approximately 2,500 feet below the surface. A zone of vigorous groundwater flow extends from the top of the seal to the water table which is approximately 600 feet below the surface.

Four productive geothermal wells have been drilled into the geothermal reservoir: HGP-A, Kapoho State 1 (KS-1), KS-2 and KS-1A. HGP-A was the discovery well for the Puna geothermal resource. KS-1, KS-2 and KS-1A were drilled by PGV subsequent to HGP-A.

GEOTHERMAL FLUIDS

Geothermal fluids have been chemically characterized through samples obtained from the four wells within the project area. The geothermal fluid chemistry varies from well to well and sample to sample. Table 2-1 lists the ranges of the chemical composition. When the fluids reach the surface and flash to steam, the majority of the dissolved minerals remain in the brine and any gases remain in the steam fraction.

Noncondensable gases (NCG) are associated with the flashed steam fraction. The observed composition of the NCG in the steam fraction is presented in Table 2-2.

Table 2-1

GEOTHERMAL FLUID CHEMICAL COMPOSITION
COMPOSITE DATA[(a)]

Element	Brine[(b)] (ppm)(w))	Steam Condensate[(b)] (ppm(w))
Na	600 - 10,000	0.17
K	123 - 2,700	0.1
Ca	40 - 920	0.1
Mg	1 - 2	<0.1
Fe	<1 - 8.4	0.05
Mn	<1 - 8.5	--
B	4 - 11	<0.5
Br	40 - 80	--
I	<20	--
F	0.2 - 0.9	--
Li	1 - 9	<0.01
Cl	925 - 21,000	<2
NH_3 (c)	<0.01 - 0.1	0.12
SO_4	9.2 - 24	13
Hg	<0.001 - <0.05	--
As	0.09 - 0.4	<0.01
$S^{=}$ (d)	5 - 100	--
Total Alkalinity	$\leq$10	<10
HCO_3	0 - 18	0
CO_3	0	0
SiO_2	420 - 1,500	0.7
TSS	70	--
TDS	2,500 - 35,000	15
pH	$\leq$5 - 5.5	3.5
Conductivity (mho/cm)	3,100 - 67,000	120
Density	1.03	--

(a) Composite data from three wells on the PGV site (KS-1, KS-1A, and KS-2) and the HGP-A well.
(b) WHP-155 psig; WHT = 368°F
(c) Concentration high due to oxidation of $S^{=}$ to SO_4.
(d) Concentration low due to oxidation of $S^{=}$ to SO_4.

Table 2-2

NONCONDENSABLE GAS COMPOSITION COMPOSITE DATA[(a)]

Element	Observed Content in Steam[(b)] ppm(w)	Design Composition ppm(w)
CO_2	250 - 1,042	956
H_2S	800 - 1,300	1950
NH_3	(c)	-
Ar	6 - 13	-
N_2	10 - 700	582
CH_4	(d)	-
He	<0.009	-
H_2	11 - 14	12
Total NCG	1,500 - 2,200	3500

(a) Composite data from three wells on the PGV site (KS-1, KS-1A, and KS-2) and the HGP-A well.
(b) WHP = 155 psig; WHT - 368°F
(c) Below Detection Limit (<1.5 ppm NH_3 in KS-1A)
(d) Below Detection Limit (<0.2 ppm CH_4 in KS-1A)

GEOTHERMAL WELLS AND WELLFIELD FACILITIES

WELL PADS

Up to six well pads are currently expected to be required over the 35-year life of the project. Currently two well pads are located on-site. Four additional well pad sites were selected on the basis of proximity to the power plant, and current knowledge of reservoir extent, optimal drilling targets, directional drilling experiences and reinjection needs. The well pad locations may be revised, as additional drilling, production, reinjection, and other information becomes available, to obtain an optimal wellfield with a low surface area requirement. The existing and proposed well pads measure approximately 400 by 300 feet and may accomodate up to four or five wells each.

Each well pad will contain a rock muffler, a separator and associated piping. Wellheads will be placed about 30-50 feet apart to allow adequate room to access each wellhead during future workover operations. The well pad rock muffler will provide noise abatement during well testing. Connections for a portable H_2S chemical abatement unit will be provided. This chemical abatement unit will be moved to the appropriate well pad during well testing.

GEOTHERMAL WELLS

The current plan anticipates about 20 geothermal wells over the 35-year life of the project. The current wellfield development plan anticipates the following types and quantities of wells:

Type	Quantity
Production Wells	6
Injection Wells	3
Makeup Wells	11
Total	20

Three of the four wells drilled into the geothermal reservoir to date are on the project site: KS-1, KS-1A and KS-2. Currently, KS-1 and KS-2 are suspended with cement plugs in their bores. KS-1A is shut-in and awaiting pipeline connection to commence a flow test to the HGP-A plant. Some or all of these wells may be used for the PGV project. All wells will be drilled to the depth of the geothermal resource. Depths will vary between 4,000 to 7,000 feet. Wells will consists of 13-3/8-inch diameter steel casing down to about 2,500 feet. A 9-5/8-inch casing will extend to about 4,100 feet. A 7-inch perforated liner will be installed from the bottom of the 9-5/8-inch casing to the bottom of the well. All casings are steel and are joined with premium threaded couplings and cemented to ensure the structural integrity of the well casing. (See Figure 2-3 for a diagram of a typical well.)

Production Wells

Each production well is anticipated to have an average flow rate of 90,000 lbs./hr. of steam deliverable to pipeline. Wellhead pressures of flowing wells are expected to range from 160 to 180 psig with wellhead temperatures expected to range from 370°F to 380°F.

Injection Wells

Fluids generated in the operation of the PGV wellfield and power plant will be reinjected into the geothermal reservoir (below 4,000 feet). The two fluid streams to be reinjected are brine and process fluid, both of which are liquids. The two separate injection systems have different handling requirements as follows:

Process Fluids Reinjection: Steam condensate and other collected liquids will contact the noncondensable gases in an absorber and dissolve the H_2S and CO_2. This liquid stream is transported through pipelines to the process fluids injection well for return to the reservoir.

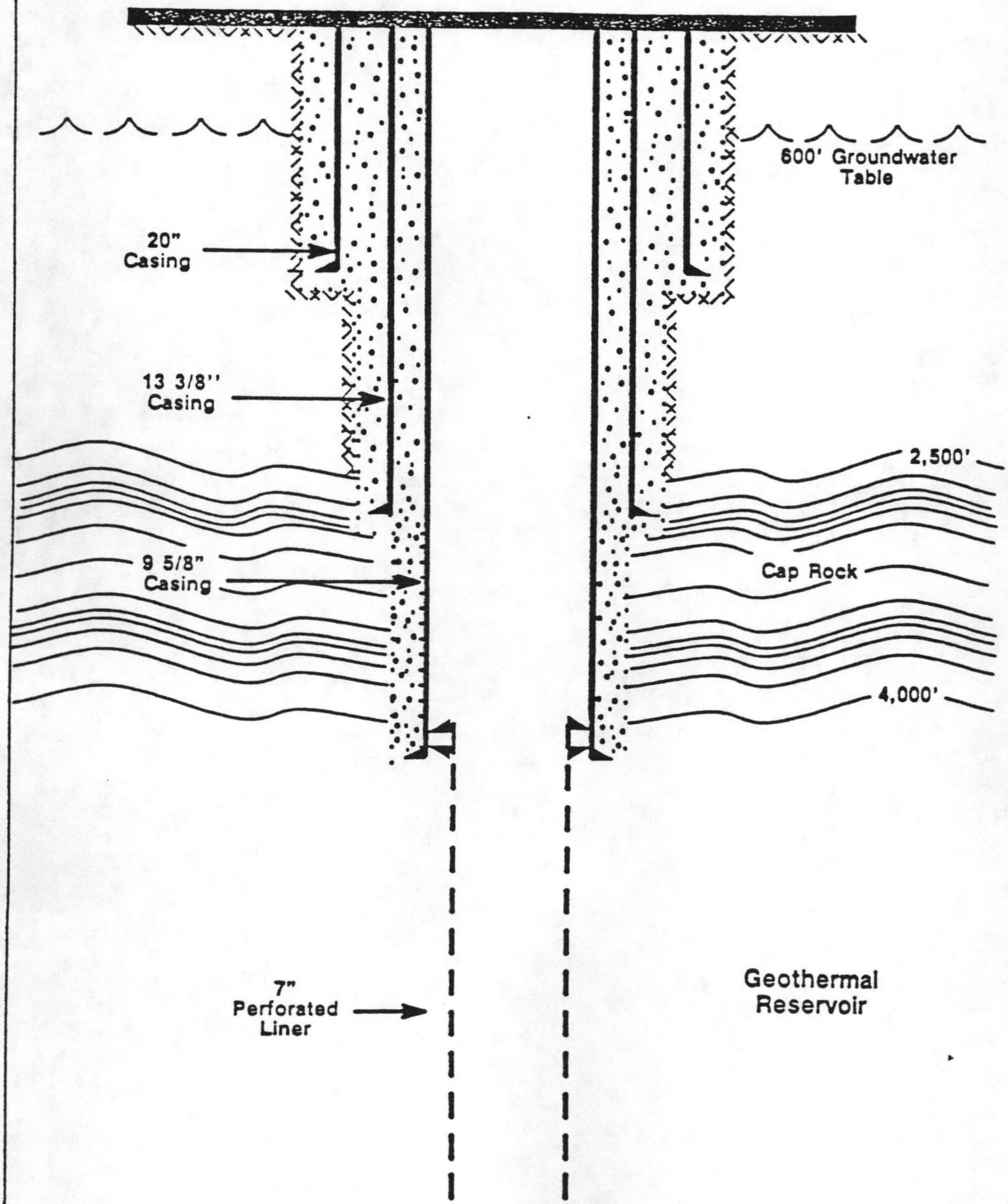


Figure 2-3
TYPICAL PGV GEOTHERMAL WELL

Brine Reinjection: Silica-laden brine recovered at each well pad separator must be quickly transported at high temperature through insulated pipelines to a brine injection well for reinjection in the reservoir. Cooling of the brine stream should be avoided as it may result in the silica precipitating out of solution.

The use of marginal geothermal production wells is preferred over drilling new wells for reinjection. Marginal production wells contain less than desired steam flow or steam fraction, and, therefore, are not efficient to use in producing electrical energy. It is likely that the brines and process fluids reinjection location will change over time in order to maximize well utilization. Three injection wells are required: one for process fluids; one for brine; and a standby which will be used as a common spare.

Makeup Wells

Individual geothermal wells may require replacement because the production or injection capability of the well has declined to a point where its contribution to the project is marginal. Makeup (replacement) wells will be drilled to maintain full plant output throughout the life of the project. Abandoned wells will be plugged with cement in accordance with procedures contained in the well drilling permits.

WELLFIELD GATHERING SYSTEMS

Gathering systems are the piping networks which collect the fluids from the individual sources and then transport the fluids to appropriate downstream processing units. Three gathering systems are used in the PGV design: steam, condensate and brine. Gathering lines generally follow the shortest route from the source to the power plant destination. This practice minimizes the heat and frictional losses during transit.

Steam Gathering System

Each well pad separator discharges steam into the steam gathering system, which then transports the steam to the turbine in the power plant. Pipeline diameters are approximately 16 inches at the well pad end and 24 inches at the power plant end.

The steam gathering system pipelines are insulated to conserve as much heat as possible and prevent condensation of part of the steam and therefore less power production.

Steam gathering system pipelines will typically be supported from 2 to 4 feet above the ground. Expansion loops will be used to prevent thermal damage to the pipes.

Brine Gathering System

The brine gathering system transports the brine separated in the well pad separators to the brine injection well. The pipelines used in the brine gathering system will be smaller in diameter than the corresponding steam gathering pipelines.

POWER PRODUCTION

The PGV power plant will be designed to provide 25 megawatts of electricity to the HELCO energy grid system. The power plant will be built with a gross capacity of 30 megawatts to deliver 25 megawatts of electricity to the HELCO system. The excess capacity will primarily be utilized by the power plant for internal energy requirements and transmission line losses. Actual operating conditions will vary the amount of electricity generated by the turbines. The power plant will consist of two units, each capable of functioning independently and supplying 12.5 megawatts to HELCO.

POLLUTION ABATEMENT AND HAZARD CONTROL

The principal pollution abatement system for H_2S is reinjection into the geothermal reservoir. Reinjection is essentially a closed loop disposal system since the fluids are returned to the same geologic zone from where they originated.

A schematic diagram of the system is shown on Figure 2-5. The primary abatement system treats the H_2S that remains in the vapor phase of the power plant condenser. More than 99 percent of the H_2S is expected to remain in the vapor due to the operating conditions in the condenser based on computer modeling. (The remaining 1 percent dissolves in the condensate and is discussed under secondary abatement.) This is called "partitioning." The HGP-A power plant, which utilizes a well that produces steam of chemical composition similar to wells on the project site, has obtained similar partitioning.

The primary abatement system removes the noncondensable gas stream from the condenser, compresses it and sends it to an absorber. The absorber mixes the noncondensable gases with excess water from the cooling tower. The H_2S and CO_2 in the noncondensable gas stream dissolve in the water while the other components (nitrogen and hydrogen) do not dissolve in the water, but are sent to the cooling tower where they are vented to the atmosphere with the cooling tower air.

Process fluids consist principally of the cooling tower blowdown, with lesser amounts of H_2S, CO_2, condensate gathering system and moisture separator fluids. The collected liquids are pumped into the process fluids injection well. Disposal by reinjection removes any need to discharge the process water at the surface. Such liquid reinjection is performed routinely at

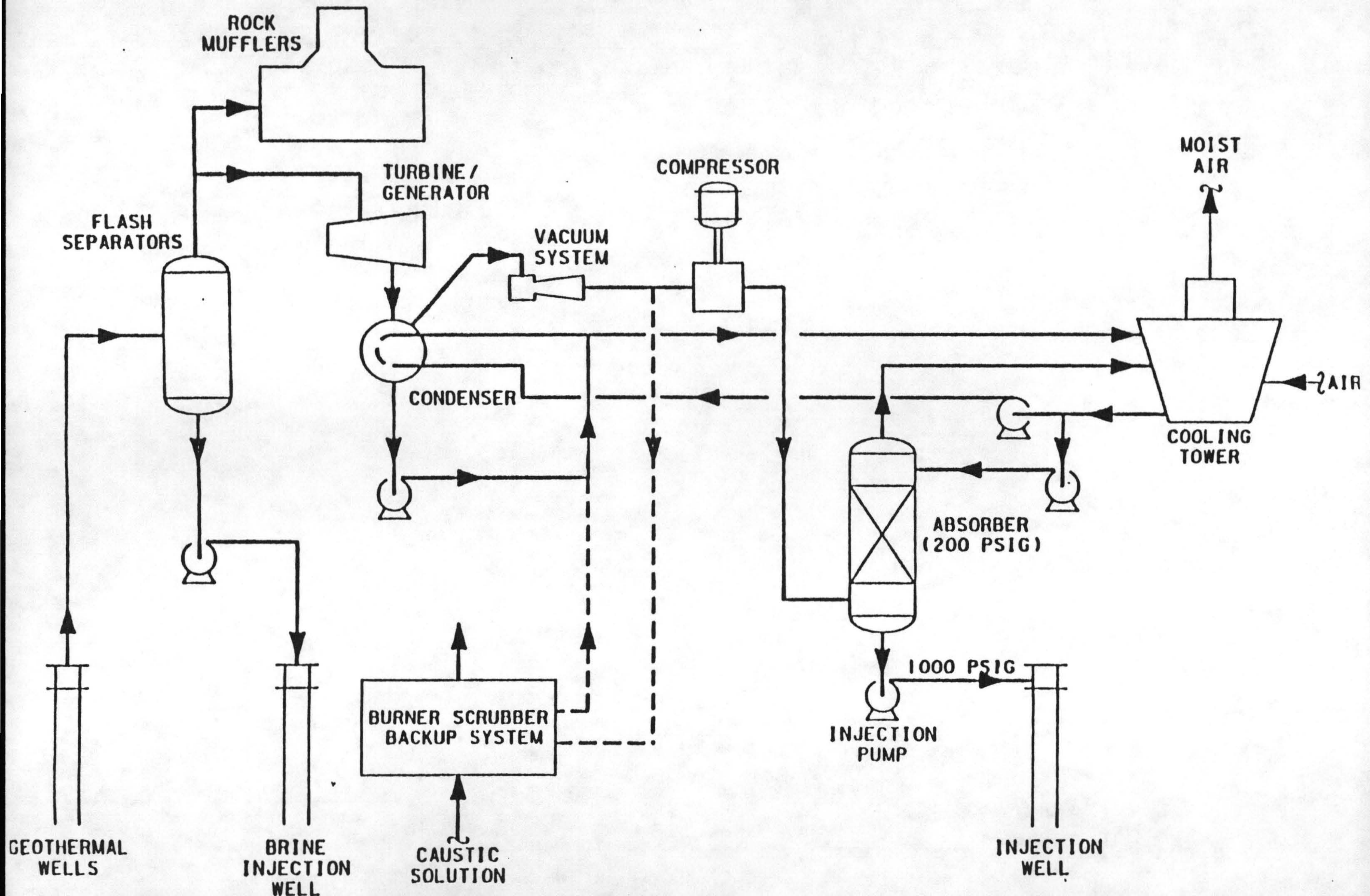

ROCK
MUFFLERS
TURBINE/
GENERATOR
COMPRESSOR
MOIST
AIR
FLASH
SEPARATORS
VACUUM
SYSTEM
CONDENSER
AIR
COOLING
TOWER
ABSORBER
(200 PSIG)
1000 PSIG
BURNER SCRUBBER
BACKUP SYSTEM
INJECTION
PUMP
GEOTHERMAL
WELLS
BRINE
INJECTION
WELL
CAUSTIC
SOLUTION
INJECTION
WELL

Figure 2-5

the Geysers in California and at other geothermal areas in the United States and around the world.

In the unlikely event that the primary abatement system has an upset or shutdown, a backup H_2S abatement system will be utilized. The backup system is a burner/scrubber system that incinerates the H_2S to SO_2 and then scrubs the noncondensable gases with sodium hydroxide converting the SO_2 to nontoxic compounds.

If the backup system is not functioning, the power plant will shut down and steam will be diverted to the steam release facility (rock muffler) and chemically abated with sodium hydroxide and hydrogen peroxide.

Cooling Tower Emissions

The steam condensate stream from the main condenser, containing less than 1 percent H_2S, is directed to the cooling tower. (The remaining 99 percent was discussed under "Primary H_2S Abatement.") It is estimated that no more than 4 pounds per hour of H_2S will be directed from the 25 megawatt plant to the cooling tower in the condensate under worst-case design criteria. Oxygen, dissolved in the cooling water, will oxidize most or all of the H_2S to sulfites under normal operating conditions, thereby resulting in nondetectable air emissions of

H_2S. In all normal operating cases, H_2S emissions would be less than 4 pounds per hour. This is less than half the limits in the proposed State emissions rules.

Brine

Brine from each well pad separator is collected and brought to the brine reinjection well through pipelines adjacent to the steam lines. The pipelines are sized according to the expected volume of flow. The total volume of fluids is anticipated to be 280 gpm; however, future wellfield development will determine the exact quantity. The lines are insulated to retain heat, thereby minimizing silica precipitation.

The brines will be combined in a pressurized brine tank where an injection pump will drive the fluids into the reservoir. If the injection wells or pumps fail, a surge pond will be available for short-term discharge.

Solid Waste

The primary and backup abatement systems will not generate any solid waste (including solid sulfur). Silica contained in the brine will be reinjected with the brine.

Noise

Anticipated noise levels have been calculated for the construction, operation and maintenance, and decommissioning phases of the project. Decommissioning noise levels will be similar to construction noise levels, except that no drilling will occur. The noise levels produced by the project will not endanger the public health of nearby residents of the wildlife in the vicinity. Adherence to Hawaii County guidelines on geothermal noise will be assured.

Noise affects hearing only when noise levels exceed 70 dBA for extended periods. Noise from the facility will be substantially below this level.

GEOLOGIC HAZARDS

The East Rift Zone has two types of potential geologic hazards: volcanic and seismic. The risks posed to structures and machinery installations can be significantly mitigated by appropriate procedures in facility siting, design, and operation.

ALTERNATIVES TO GEOTHERMAL POWER PRODUCTION

Eleven alternative energy sources were analyzed relative to the unique characteristics and specific power requirements of the Big Island. These sources are:

- Fuel oil
- Coal
- Nuclear
- Hydroelectric
- Wind
- Biomass
- Municipal Solid Waste
- Solar Thermal
- Photovoltaic
- Ocean Thermal Energy Conversion
- Ocean Wave

The present state of technology for each alternative as well as cost estimated for future years were studied.

The key factors discussed for each alternative are summarized in comparison with geothermal energy in Table 14-1. All of the alternatives are not technically feasible on a 25 megawatt scale at the present time. Some alternatives are not economically feasible. The size of the plant or technical

Table 14-1
SUMMARY OF ENERGY SOURCE CHARACTERISTICS
(on 25 MW basis)

	Technically Feasible	Economically Feasible	Resources Are Indigenous To Island	Baseload Capacity	Potential Environmental Concerns
Fuel Oil	YES	YES	NO	YES	SOx, NOx, CO, CO_2, and HC emissions.
Coal	YES	YES	NO	YES	SOx, NOx, CO, CO_2, HC, and particulate emissions.
Nuclear	YES	NO	NO	YES	High-level radioactive by-products.
Hydroelectric	YES	YES	YES	NO	Land Use.
Wind	YES	YES	YES	NO	System stability; land use.
Biomass	YES	YES	YES	YES	SOx, NOx, CO, CO_2, HC and particulate emissions; land use.
Municipal Solid Waste	YES	YES	YES	NO	SOx, NOx, CO, CO_2, HC and particulate emissions; hazardous waste.
Solar Thermal	YES	NO	YES	NO	
PV	YES	NO	YES	NO	Land use.
OTEC	YES	NO	YES	NO	
Ocean Wave	NO	NO	YES	NO	
Geothermal	YES	YES	YES	YES	H_2S emissions.

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shortcomings preclude them from being cost-competitive. Resources indigenous to the island of Hawaii are given special consideration. The intermittent or inadequate nature of some of the alternatives prevents them from having the capacity to produce 25 megawatts of baseload energy. Environmental impact concerns are noted as they apply to each alternative.

The emission level of five criteria pollutants are compared in Table 14-2 for fuel oil, geothermal, biomass (wood), and municipal solid waste (MSW) energy sources. The five pollutants presented are particulates, sulfur (SO_2), nitrogen (NO_2), carbon monoxide, and hydrocarbons. These emission levels are those that would exist during operating conditions without pollution control equipment. Therefore, they represent worst-case conditions. Figure 14-2 provides a graphic comparison of fuel oil and geothermal energy sources.

CABEIS

TABLE 14-2

EMISSION LEVELS ON A 30 MW BASIS
(LB EMITTED/HR)

	PARTICULATES	SULFUR AS SO2	NITROGEN NO2	CARBON MONOXIDE	HYDROCARBONS
FUEL OIL	4.5	160	45	11	1.1
COAL	2100	300	262	6.6	2.6
GEOTHERMAL	---	8	---	---	---
BIOMASS (WOOD)	433	7.4	138	200	98
MSW	1700	142	170	1990	85

FIGURE 14-2

EMISSION LEVELS ON A 30 MW BASIS